An illuminating reaction

By: Catherine Matthews

Matthews, C. (1996). An Illuminating Reaction. *The Science Teacher, 63* (5), 30 - 31.

CARBIDE LIGHTS OFFER AN EXCELLENT mechanism for introducing or reviewing many basic chemistry concepts, including elements and compounds, endothermic and exothermic reactions, physical and chemical changes, and balancing chemical equations.

A carbide light is a lamp that combines water from an upper chamber with calcium carbide in a lower chamber. When water drips onto the calcium carbide, acetylene gas is produced. The gas flows to the top of the lamp and out through a hole at the tip of the light. A piece of flint is used to generate a spark, which ignites the gas.

WHO USES CARBIDE LIGHTS?

The design of the carbide, or acetylene, lamp has changed little over the 100 years it has been in use. By 1900 most metal miners used acetylene lamps. These lights were carried by handle and hook or mounted on the brim of a helmet. Acetylene lights were also used as bicycle and automobile lights. One of the first acetylene bicycle lamps was produced in 1888 in the United States and was known as the "20th Century." After 1930 acetylene lamps in automobiles were replaced by electric lights.

Cave explorers (spelunkers) use carbide lights today. Because the lamps deliver heat, they can be used to prevent hypothermia or heat drinks. They also weigh less and provide more light per unit volume than electric lights.

ILLUMINATING CHEMISTRY

Carbide lights can be used to teach a number of chemistry concepts. A good place to start for beginning chemistry students is reviewing chemical formulas using the reaction that occurs in a carbide light:

CaC^sub 2^(S) + 2H^sub 2^0(1)--> Ca(OH)^sub 2^(S) + C^sub 2^H^sub 2^(g).

Students will recognize the formula for water. From this familiar starting point, you can proceed to review the rules for naming compounds and for creating chemical formulas.

The carbide light reaction is easy to balance, especially if students represent water as a hydroxide ion and a hydronium ion. On the right side of the equation, there are two hydroxide ions. Therefore there must be a coefficient of two for water on the left side.

Before demonstrating the carbide light, I address the safety concerns associated with the demonstration. I discuss flammable substances and substances that are strong bases. Caution: Acetylene is extremely flammable and explosive. To avoid the possibility of an explosion, you must limit your use of carbide to less than 350 grams total during the day that you conduct these activities.

Also before the demonstration, I review the terms reactant and product so that students can observe the reactants and products involved in the carbide light reaction during the demonstration. Students should describe as many of the observable properties as possible of the two reactants: a colorless, odorless liquid that appears to have a viscosity similar to that of water and a grayish-black solid with a powdery texture that has a sulfurous odor and looks like gravel or small rocks. Students' descriptions of the products should include a colorless, very flammable gas with a distinct sulfurous odor and a grayish-white, powdery semisolid.

The carbide light reaction also provides an opportunity to review the differences between physical changes (reactants are the same as the products) and chemical changes (reactants are different than the products). This, of course, is an example of a chemical reaction. Students should be able to deduce that this is a chemical reaction because a flammable gas, a new compound, is produced in the reaction.

The carbide light reaction is an excellent example of an exothermic reaction. I ask students why there is a rubber ring surrounding the brass container for the calcium carbide. Then I remove one rubber ring from one carbide light and leave another attached to the brass bottom of another carbide light. Students hold the containers and note changes in temperature as the reaction occurs. Be sure to tell students to set the lights down carefully when their hands start to get warm. Students quickly conclude that this reaction gives off heat. I extend this discussion by relating this discovery to a discussion of conductors and insulators of heat. Rubber is obviously a poor conductor of heat and therefore a good insulator. Brass is a good conductor of heat and therefore a poor insulator.

The carbide light reaction also lends itself to a discussion of acidity and basicity. Calcium hydroxide is a strong base and can provide an opportunity for students (wearing proper safety attire) to measure basicity. It can also illustrate difficulties with measuring devices. To accurately measure the acidity of a substance, pH paper must be in contact with a liquid substance or be damp itself. However, in attempting to measure the pH of calcium carbide, a chemical reaction ensues when the moist pH paper touches the calcium carbide. Therefore, the question arises as to what substance's pH is actually measured.

EXTENSIONS

The mechanics of the carbide light offer more lessons. Giving students the chance to assemble and disassemble the lights allows them to see the logic behind the lights' engineering. Loading the lights properly with the two reactants and successfully lighting them give students a sense of achievement. Many students have had few opportunities to actually assemble devices that depend on chemical reactions.

The commercial production of calcium carbide makes an interesting real-world connection to this activity. Calcium carbide is an important commercial product made by heating quicklime (calcium oxide) with coke in an electric furnace. Coke is a solid product consisting of ash and carbon residue that remains after coal is heated in the absence of air. Calcium carbide hydrolyzes in water to form acetylene, which is used in the synthesis of many organic materials, including synthetic fabrics and plastics.

Carbide lights can be used in the classroom to illuminate students' understanding of chemistry terminology, which often clouds students' comprehension of chemistry concepts. When students see, feel, and smell evidence of an exothermic chemical reaction, terminology becomes more meaningful. Identifying reactants and products and balancing a chemical equation that produces potentially dangerous substances takes on new significance-it becomes a personal experience, not just a chemistry experiment.

NOTE

For information on obtaining carbide lights, contact The National Speleological Society at 2813 Cave Avenue, Huntsville, AL 35810; (205) 852-1300. The Society will direct you to caving supply dealers who carry these lamps. The Premier, at approximately $35, is your best bet for a quality brass carbide light.

REFERENCES

Caunter, C. R. 1955. The History and Development of Cycles. London: Her Majesty's Stationery Office.

Gregory, C. E. 1980.A Concise History of Mining. New York: Pergamon Press. Larson, L. and P. Larson. 1982. The Sierra Club Guide to Spelunking. San Francisco: Sierra Club Books. McClurg, D. 1980. Exploring Caves: A Guide to the Under ground Wilderness. Harrisburg, Penn.: Stackpole.